

Internal iliac occlusion without coil embolization during endovascular abdominal aortic aneurysm repair

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Purpose: When abdominal aortic aneurysms and common iliac artery (CIA) aneurysms undergo concomitant endovascular repair, endograft limb extension into the external iliac artery is often necessary. Usually, the internal iliac artery (IIA) is coil embolized in such a case to prevent endoleak. It has been our practice to coil embolize the IIA only in cases where there is not adequate stent graft seal in the CIA immediately proximal to the IIA origin (effectively sealing the entire IIA origin). In this study, we evaluated the outcomes of this approach.

Methods: We retrospectively reviewed 204 consecutive endovascular abdominal aortic aneurysm repairs at Dartmouth-Hitchcock Medical Center from 1996 to 2001. Computed tomographic angiography with three-dimensional reconstruction was the primary preoperative imaging modality, and the decision to cover the IIA without concomitant coil embolization was based before surgery on the presence of adequate graft oversizing ($\geq 10\%$ to 15%) in the most distal 5 mm of CIA and 15 mm of proximal external iliac artery, respectively.

Results: The IIA was occluded 33 times in 31 patients. In 22 cases (67%), the IIA was covered without coil embolization (COVER group). The remaining 11 patients (33%) with inadequate graft oversizing in the CIA underwent IIA coil embolization (COIL group). The follow-up periods for the COVER and COIL groups were 19 ± 2 months and 10 ± 3 months, respectively. All operations in both groups were technically successful without evidence of endoleak at completion angiography. No endoleaks, graft migrations, or aneurysm enlargements were associated with the covered or coiled IIAs during the follow-up period. No clinical sequelae were seen in the COVER group, with the exception of buttock claudication in six patients (27%) that resolved completely in five patients. In the COIL group, five patients (45%) had buttock claudication. In addition, one case of buttock necrosis and one case of ischemic neuropathy occurred in the COIL group.

Conclusion: Covering the IIA without coiling effectively excluded the CIA aneurysm in every case and was associated with a low incidence rate of complications compared with coil embolization. With detailed preoperative imaging and patient selection, IIA coil embolization may not be necessary in as many as two thirds of patients who need IIA occlusion. (*J Vasc Surg* 2002;36:1138-45.)

Endovascular abdominal aortic aneurysm (AAA) repair (EVAR) is applied to a large variety of aortic aneurysm configurations. Approximately 20% to 30% of patients with AAAs have associated aneurysms of at least one common iliac artery (CIA),^{1,2} which makes endovascular management of the internal iliac artery (IIA) potentially important. Early aortic stent grafts had small distal limbs that were unable to accommodate large or ectatic common iliac arteries. More recently, large common iliac arteries (less than 20 mm in diameter but free of aneurysms at the attachment site) have been treated with a "bell-bottom" technique to preserve the IIA.³⁻⁵ Conversely, manufacturer

recommendations for minimal iliac seal zone length (per manufacturer instructions for use and clinical trial protocols) have increased from 10 mm to at least 15 to 20 mm in many cases. This means that graft limb extension into the external iliac artery (EIA), covering the IIA, is more frequently necessary in patients who desire endovascular repair. When the stent graft must be extended into the EIA, coil embolization of the IIA is usually used to prevent endoleak.^{3,4,6-16} Operative ligation, transposition, or bypass of the IIA have also been proposed as adjuncts to EVAR but are infrequently used.^{17,18} Reporting of stent graft coverage of the IIA without coil embolization has to this point been limited to instances of inadvertent coverage during stent graft deployment or cases where attempts at coil embolization failed technically.^{3,9,11}

In our series of EVARs, the decision to cover the IIA without concomitant coil embolization was made before surgery and was on the basis of the presence of adequate graft oversizing ($\geq 10\%$ to 15%) in the most distal 5 mm of CIA and the most proximal 15 mm of EIA, respectively. We hypothesized that this technique would be effective in preventing distal attachment endoleaks while possibly avoiding some of the morbidity associated with IIA coil

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embolization. To our knowledge, this is the first substantial series of preoperatively planning for intentional IIA coverage without coil embolization.

METHODS

Patient cohort. We retrospectively reviewed our database of 204 consecutive EVARs performed at Dartmouth-Hitchcock Medical Center from June 1996 to December 2001. This period encompasses all “learning curve” patients, patients in clinical trials, and subsequent commercial implantations.

Imaging. The primary preoperative imaging method in all patients was spiral computed tomography (CT) in conjunction with three-dimensional (3D) reconstruction and computer-aided measurement, planning and simulation (CAMPS) software (Preview, Medical Media Systems, West Lebanon, NH). Details of the protocol have been previously described.¹⁹⁻²² Arterial diameter measurements were made with CT scan reformats perpendicular to the vessel with interactive real-time display of the CT scan slices and measurements in the context of the 3D reconstruction.²⁰⁻²² Measurements of seal/fixation length and lengths over the graft path were also calculated with this software. Preoperative angiography was never required for this purpose, but the initial 35 of 204 patients had confirmatory angiographic and intravascular ultrasound scan measurements performed during surgery. The proposed stent graft was simulated in the patient’s 3D anatomy (a technique we termed “virtual endograft”), with anticipation that the stent graft would generally follow the lumen centerline but allowing simulations that followed a user-defined path as well.¹⁹ Detailed preoperative planning was used to anticipate difficult aortoiliac anatomy and the stent graft endpoints to evaluate patient suitability for preserving the IIA or the need for coil embolization if the IIA had to be covered.

Anatomic considerations for coil/cover versus cover only. Among patients that needed extension of the endograft limb into the EIA, the decision to cover the IIA without concomitant coil embolization was based before surgery on the presence of adequate graft oversizing in the most distal 5 mm of CIA and the most proximal 15 mm of EIA. Graft oversizing was considered separately for the distal CIA and EIA and was considered adequate if the graft limb diameter was 10% to 15% or more than the adventitial diameter of the native vessel. For some endografts, tapered limbs or extensions were available to more easily accommodate this strategy. Examples of appropriate anatomy for stent graft coverage of the IIA with and without coiling are shown in Fig 1.

Indications. The anatomic indications for IIA coverage were: AAA with unilateral CIA ($n = 17$), AAA with bilateral CIA ($n = 5$), AAA with unilateral IIA ($n = 1$), AAA with iliac artery ectasia ($n = 4$), secondary loss of common iliac fixation from stent graft deformation or progression of CIA pathology ($n = 3$), and inadvertent IIA coverage from deployment problems with the primary graft or related to misinterpretation of the intraoperative angio-

gram early in our endograft experience ($n = 3$). If there was a discrepancy between the intraoperative angiogram and the preoperative 3D “virtual graft” simulation, we no longer assumed that the angiogram appearance was correct. No IIAs were inadvertently covered because of preoperative measurement or planning issues. A chronically occluded IIA was intentionally covered in four cases, but these were excluded from this series. IIAs were not covered if a stent graft of adequate diameter was available to seal in a nonaneurysmal CIA.

Intraoperative. All EVARs were performed in the operating room with a 12-in digital C-arm fluoroscopy unit (Philips BV 312, The Netherlands, or GE/OEC 9800, Salt Lake City, Utah). Examples of intraoperative arteriograms are shown in Fig 2. General anesthesia was used in 67% of cases, and regional anesthesia (epidural or continuous spinal) was used in the remainder. The following stent grafts were used: AneuRx (Medtronic AVE, Santa Rosa, Calif; $n = 20$), Excluder (WL Gore, Flagstaff, Ariz; $n = 7$), Vanguard I & II (Boston Scientific, Medox Medicals, Oakland, NJ; $n = 7$), and EVT (Guidant, Menlo Park, Calif; $n = 1$). Unilateral IIA occlusion with or without coil embolization was performed at the time of primary stent graft placement ($n = 32$) or during endovascular revision ($n = 3$). When coil embolization was performed, it was during the same operative setting, just before endovascular graft deployment. Coils (0.038” tornado coils, Cook, Bloomington, Ind) were preferentially placed in the proximal IIA ($n = 6$; 55%), between the origin and first branch point. Four patients (36%) had coils placed in first order branches of the IIA when the IIA origin was too short, for dilated but not aneurysmal IIAs, or because of inadvertent distal coil migration. In one patient (9%) with an IIA aneurysm, individual outflow vessel occlusions were performed in first and second order branches to obtain exclusion. In the two patients with bilateral IIA occlusions, the second occlusion was performed during a revision, not during the original procedure.

Postoperative follow-up. Patients were seen in the follow-up period at 1, 6, and 12 months, with annual visits thereafter. Interim visits were scheduled as clinically indicated or per manufacturer recommendations for clinical trial patients. Each visit included a patient interview, review of systems, physical examination, ankle-brachial indices, CT scan with 3D reconstruction including computer-aided volume measurements, and plain abdominal radiographs (four views). Claudication was categorized as severe if it interfered with the patient’s daily activities and mild if there was minimal impact on lifestyle. No patients fell into an intermediate category.

RESULTS

Stent graft coverage of the IIA (with or without IIA coil embolization) was performed 33 times in 31 patients for the indications cited previously. Comorbidities reflect the high-risk patient population for this procedure and were similar in patients undergoing stent graft coverage plus coil embolization ($n = 11$) or stent graft coverage alone ($n =$

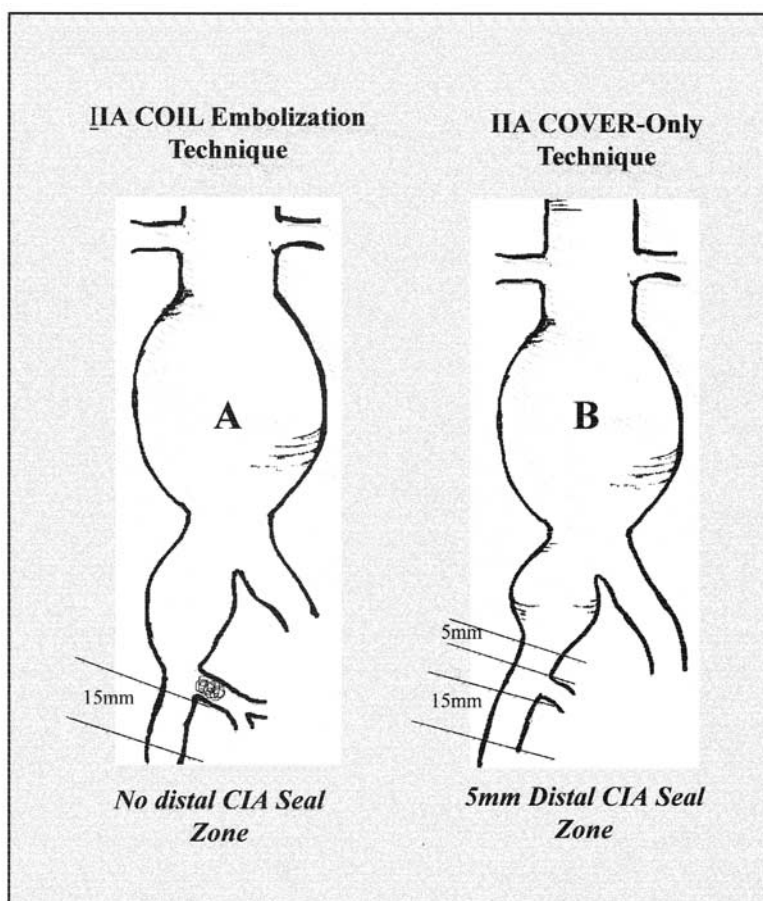


Fig 1. Anatomic criteria for standard and cover only techniques in patients who need endograft extension into external iliac. **A**, IIA coil embolization is required because of absence of seal in distal CIA. **B**, Presence of distal CIA seal zone (≥ 5 mm length) is needed for IIA coverage without coil embolization.

22; Table I). All operations were technically successful in excluding the AAA and IIA as intended, without arterial injury, endoleak, colon ischemia, or mortality. The mean follow-up period for patients with stent graft coverage alone (COVER group) was 19 ± 2 months, compared with 10 ± 3 months for the patients undergoing stent graft coverage plus coil embolization (COIL group). No patients were lost to follow-up. Four patients died during the follow-up interval, each of causes unrelated to EVAR or IIA occlusion.

In-hospital complications were mild and similar between groups. One patient in each group had silent transient myocardial ischemia that was not believed to represent infarction (detected with serial troponin measurements alone). Perioperative arrhythmias, one in each group, were self limited and required no antiarrhythmia medications. There was one instance of transient renal insufficiency (creatinine level increase from 1.2 to 1.7) that resolved within 2 days in a COVER group patient, presumably related to contrast nephropathy. No patients needed dialysis.

Postoperative ankle-brachial indices in all cases did not differ significantly from preoperative values. Mean length of stay was 1.6 ± 0.2 days for the COVER group and 2.2 ± 0.8 days for the COIL group. Intensive care usage was minimal: COVER, 0.0 day; versus COIL, 0.4 ± 0.4 day. The perioperative (30-day) mortality rate was zero.

Endovascular graft-associated complications. After surgery, there were no endoleaks, stent graft migrations, or aneurysm enlargements associated with IIA occlusion. There were two type II endoleaks contained within the aorta, associated only with patent lumbar arteries and without any connection to the common or IIA on either side; one was successfully treated with lumbar artery coil embolization (via the remaining patent IIA), and the second was under observation with no increase in aneurysm sac volume or diameter at 1 year follow-up. These were not believed to be related to IIA occlusion and did not differ from the endoleak rate observed in the remainder of our patients for EVAR. There were two limb occlusions ipsilateral to the covered IIA: one late (28 months) and one early (2 weeks), both treated with femoral-femoral bypass. The late occlu-

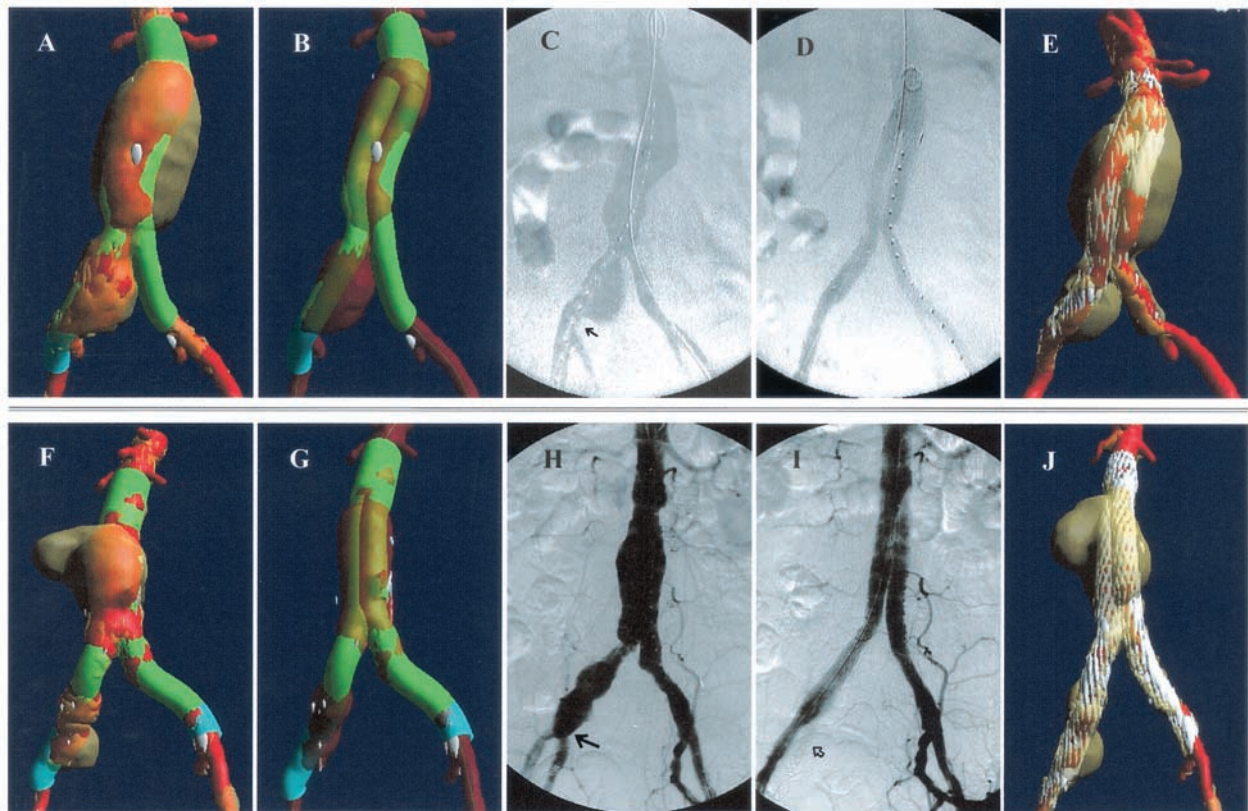


Fig 2. Representative perioperative images of cover only (A to E) and coil embolization (F to J) techniques. **A**, Preoperative 3D reconstruction with CAMPS showing virtual Excluder endograft. AAA and right CIA aneurysm are seen with thrombus. **B**, Same view in **A** with thrombus removed to show detail of virtual graft (green) with right EIA extension (blue) covering IIA origin. **C** and **D**, Intraoperative arteriograms (gadolinium) showing 5-mm distal CIA seal zone (arrow). Completion arteriogram (**D**) shows IIA coverage and complete exclusion of aneurysms. **E**, One-month follow-up 3D reconstruction with CAMPS shows no endoleak. **F**, Preoperative 3D reconstruction with CAMPS of AAA and right CIA aneurysms (thrombus visible) with virtual AneuRx endograft. **G**, Same view with thrombus removed. Right IIA is patent and easier to see when model is rotated. **H** and **I**, Intraoperative arteriograms showing right CIA without adequate distal CIA seal (large arrow) requiring IIA coil embolization (open arrow) before coverage with stent graft. **J**, One month follow-up 3D reconstruction with CAMPS shows no endoleak.

sion occurred from severe graft deformation associated with AAA shrinkage, and the early occlusion was managed at an outside hospital with no attempt to discern the reason for the occlusion (subsequent CT scan, 3D images, and abdominal films indicated no stent graft deformation). The aneurysm-related mortality rate was zero at the limits of follow-up.

IIA occlusion-associated complications. The incidence rate of postoperative lower extremity ischemic symptoms was statistically similar for the two groups but tended to be more severe in the COIL group. There were no clinical sequelae in the COVER group, with the exception of mild buttock claudication in six of 22 patients (27%). Claudication resolved in all COVER group patients with unilateral coverage, most within 1 year. One patient who had bilateral IIA covering still had of mild bilateral buttock claudication at the time of the last follow-up, 12 months after surgery. No COVER group patients had severe clau-

dication, lower extremity neurologic symptoms, or new onset erectile dysfunction. There were no cases of colon ischemia or buttock necrosis in the COVER group.

COIL group patients had buttock claudication in five of 11 cases (45%; $P = .3$ versus COVER group patients), which was considered to be severe (lifestyle limiting) in two. Severe buttock claudication resolved completely within 3.3 months in one patient and persisted at 6 months in the other patient. Two COIL group patients had mild persistent buttock claudication at 1.4 months and 14 months after surgery. Two COIL group patients had more serious complications that were probably related to coil embolization. One patient who had evidence of lower extremity embolization before surgery appeared to have further evidence of emboli immediately after surgery, with petechiae, superficial buttock ulcers, transient motor weakness, and neuropathic pain. The buttock ulcer and weakness resolved by 3.8 months with local wound care and

Table I. Patient demographics

	<i>Cover without coiling</i>	<i>Coil embolization (n = 11)</i>
Age (y)	72.3 ± 2	70 ± 1.6
Gender (percent male)	82%	91%
Arrhythmia	14%	9%
ASA ≥ III	74%	80%
CAD	71%	71%
Cerebrovascular disease	19%	36%
COPD	43%	55%
Hypercholesterolemia	37%	45%
Hypertension	81%	82%
PVOD	14%	18%
Smoking history	85%	100%
Active smoker	29%	30%
Preoperative creatinine level	1.0 ± 0.17	1.23 ± 0.32

For each variable, differences between groups were not statistically significant.

ASA, American Society of Anesthesiologists; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; PVOD, peripheral vascular occlusive disease.

physical therapy, but the patient continued to have some neuropathic symptoms at 18 months follow-up. The other serious complication occurred in a patient who had symptomatic spinal stenosis before surgery, including bowel dysfunction. After surgery, buttock claudication, ipsilateral thigh paresthesias, and fecal and urinary incontinence developed and persist at 6 months of follow-up. Although no definite correlation between coil location within the IIA and degree of pelvic ischemic symptoms could be made, both patients with severe complications had needed coil embolization of IIA branches beyond the main trunk to achieve occlusion.

DISCUSSION

As EVAR is applied to increasing numbers of patients, it is important to continue evaluation of its safety and efficacy relative to the proven surgical procedure it is designed to replace. Interestingly, the risk of pelvic ischemia associated with IIA occlusion has been somewhat higher in endovascular series than in open surgical series.^{12,23-26} Speculation regarding this difference has centered around IIA branch coil embolization beyond the main trunk combined with interruption of other pelvic collateral circulation during endovascular repair, without the option of more proximal IIA occlusion or inferior mesenteric artery reimplantation available during open repair.^{7,16} Mehta *et al*¹² have reported the largest series of IIA occlusions performed during endovascular (n = 107) and open (n = 47) aortoiliac aneurysm repairs. For that series, the only ischemic complication that was marginally higher in the open repair group was colon ischemia (open, 4%; versus endovascular coil embolization, 2%). Colon ischemia was absent in both the COIL and COVER groups in our series. With regard to other symptoms, however, Mehta *et al*¹² reported that only one patient in the open group (2%) had persistent claudication (after bilateral IIA ligation), whereas 17 patients in

the endovascular group (16%) continued to report claudication at 1 year. The initial claudication rate (reported for endovascular and open groups combined) was much higher (36% after unilateral occlusion, 40% after bilateral occlusion), showing the significant improvement experienced by most patients. Our COIL cohort, although small, shows an initial rate of pelvic ischemia symptoms (45%) similar to other reports.^{11,12,15} Although our COIL group also showed fairly rapid and substantial improvement, two patients had significant adverse events that were probably related to coil embolization. The rate of initial pelvic ischemia symptoms in our COVER group (25%) appears lower than in our COIL group (although the results are statistically similar in this small sample) and is comparable with the lowest rates reported in the literature (Table II). There were no embolic events in the COVER group; mild claudication was the only symptom, and the claudication resolved completely in five of six patients. Although the series was too small to draw strong conclusions, this degree of improvement is better than other reports. The only COVER group patient who did not have complete resolution of symptoms had bilateral IIA occlusions (<5% of COVER group). Of course, improvement can be subjective and would need to be better evaluated with a disability scoring system.^{11,16}

Thus, although the available information is not substantial, it appears that the technique used for IIA occlusion may relate to the number and severity of ischemic complications. It is well documented that the incidence rate of buttock claudication is lower in open series where the IIA is ligated precisely at its origin. It seems logical that the endovascular technique that comes closest to duplicating surgical ligation would also have the lowest associated incidence rate of pelvic ischemia. Covering and sealing the IIA orifice without coil embolization most closely approximates surgical ligation and may have a lower incidence of acute and chronic complications related to ischemia. Presumably, the "cover only" technique has the least potential to cause distal embolization or interruption of IIA collaterals. When coil embolization is used, data from this series and others suggest that more proximal placement of coils within the primary IIA trunk has less potential for distal thromboembolization or interruption of important pelvic collaterals than coil embolization of distal IIA branches.⁷ In addition, the risk of atheroembolization resulting from coil embolization may also be higher because it entails more catheter manipulations within aneurysmal vessels.

Of course, the objective of IIA occlusion during EVAR is to effectively prevent the potential of an IIA-associated branch endoleak while providing a better attachment site for fixation and sealing in the nonaneurysmal EIA. Thus, the primary concern regarding stent graft coverage of the IIA without coil embolization is the potential for endoleak. In this series, there were no attachment site (type I) or iliac branch (type II) endoleaks in either the COVER or COIL group. Clearly, not all patients are candidates for stent graft coverage without coil embolization, and sophisticated preoperative imaging is likely crucial for appropriate patient

Table II. Recently published series of IIA occlusions as part of EVAR

Author	Mean follow-up (mo)	No. total EVG	No. IIA occlusion	Method of IIA occlusion				Adverse events			
				No. cover, without coiling			Operative ligation	Buttock claudication	Buttock necrosis	Colon ischemia	IIA-associated endoleak
				No. coil	Intentional	Unintentional or unplanned					
Rhee et al ³ (2002)	4.6	228	49* (21)	35 (71)	0	6 (12)	2 (4)	14 (28)	1 (2)	0	0
Lee W et al ¹¹ (2001)	14.4	157	23 (15)	10 (43)	0	13 (57)	0	9 (39)	0	0	0
Karch et al ⁹ (2000)	13.4	96	24 (25)	15 (62)	0	9† (38)	0	7 (32)	0	3 (12)	0
Lee C et al ¹⁰ (2000)	7.3	94	28 (30)	13 (46)	9 (32)	9 (32)	0	5 (18)	1 (3.6)	0	0
Wolpert et al ¹⁵ (2001)	nr	65	18 (28)	18 (100)	nr	nr	0	8 (44)	0	0	0
Criado et al ¹⁴ (2000)	11.5	156	39 (25)	39 (100)	0	nr	0	5 (13)	0	0	0
Cynamon et al ⁷ (2000)	18	nr	34 (?)	34 (100)	0	nr	0	13 (38)	0	0	1 (3)
Wyers et al (2002)	18.5 ^{cov} 10.2 ^{cl}	204	33 (16)	11 (33)	19 (58)	3 (9)	0	6 ^{cov} (27) 5 ^{cl} (45)	0 ^{cov} 1 ^{cl} (9)	0 ^{cov} 0 ^{cl}	0 ^{cov} 0 ^{cov}

Numbers in parentheses are percentages. Percent IIA occlusions are percent of total endovascular graft (EVG) repairs. Methods of IIA occlusion and adverse events are shown as absolute number and as percent of IIA occlusions.

*Six patients in this series underwent IIA revascularizations.

†Five from traumatic dissection, four accidentally covered with stent graft.

nr, Not reported; cov, cover only; cl, coiled.

selection and durable results. We also use 3D reconstruction and CAMPS to preoperatively select the appropriate intraoperative C-arm gantry angle for IIA visualization to ensure appropriate stent graft placement.^{19,22} Nonetheless, it appears that the cover only technique could be used in a much larger percentage of cases than have been reported to date.

Other groups have reported small numbers of IIA coverage without coil embolization as part of a cohort of patients who underwent IIA embolization (Table II). In most situations, this subset of patients without coil embolization was the result of inadvertent coverage of the IIA from inaccurate preoperative length measurements, iliac artery access difficulty with iliac injury, or stent graft deployment-related problems.^{9,11} Most of these complications can be avoided or minimized with state-of-the-art preoperative imaging with detailed evaluation of the access path and the entire area of stent graft fixation.^{19,22} Intentional covering of the IIA has been reported in a small number of cases after failed embolization attempts, most commonly from a severe IIA origin stenosis that prevented catheterization of the vessel. The incidence rate of pelvic ischemia in this particular situation is arguably very low given that collaterals are already in place. Of course, some stent graft deployment-related problems are graft specific, mechanical in nature, and unrelated to preoperative imaging. The incidence rate of these problems should be low, however. Unintentional and unplanned IIA coverage occurred in only three patients (1.5%) from our entire endograft series. None of these were the result of measure-

ment or graft sizing errors. This represents the lowest rate in the literature and is likely related to careful preoperative evaluation of the patient's anatomy (including CIA, IIA, and EIA anatomy) with CT angiography, 3D reconstruction, and CAMPS.

CONCLUSION

Stent graft coverage of the IIA without coil embolization can be performed safely at the time of endovascular repair of aortic and iliac aneurysms and is applicable in up to two thirds of patients who need endograft extension into the EIA. This technique is simple, requires no additional equipment, minimizes intervention, and reduces cost. The cover only technique, applied to properly selected patients, is effective in the prevention of internal iliac-associated endoleak. Complications of acute and chronic ischemia appear less frequent and less severe when the IIA is covered without coil embolization, although this trend did not reach statistical significance in this modest series. Severe complications are rare with IIA occlusion of either type and in this series occurred only in patients who needed embolization of distal IIA branches. This also seems to be a trend in the literature, and coil embolization of distal IIA branches should be avoided when possible. Unfortunately, in the literature reported to date, most of the cover only cases were unintentional. Careful preoperative evaluation of the distal CIA, IIA, and EIA anatomy with CT angiography, 3D reconstruction, and CAMPS is extremely helpful in determining the appropriate approach to complex iliac

artery anatomy and may be responsible for the low incidence rate of inadvertent coverage in this series.

REFERENCES

- Armon MP, Wenham PW, Whitaker SC, Gregson RH, Hopkinson BR. Common iliac artery aneurysms in patients with abdominal aortic aneurysms. *Eur J Vasc Endovasc Surg* 1998;15:255-7.
- Henretta JP, Karch LA, Hodgson KJ, Mattos MA, Ramsey DE, McLafferty R, et al. Special iliac artery considerations during aneurysm endografting. *Am J Surg* 1999;178:212-8.
- Rhee RY, Muluk SC, Tzeng E, Missig-Carroll N, Makaroun MS. Can the internal iliac artery be safely covered during endovascular repair of abdominal aortic and iliac artery aneurysms? *Ann Vasc Surg* 2002;16:29-36.
- Criado FJ, Wilson EP, Velazquez OC, Carpenter JP, Barker C, Wellons E, et al. Safety of coil embolization of the internal iliac artery in endovascular grafting of abdominal aortic aneurysms. *J Vasc Surg* 2000;32:684-8.
- Karch LA, Hodgson KJ, Mattos MA, Bohannon WT, Ramsey DE, McLafferty RB. Management of ectatic, nonaneurysmal iliac arteries during endoluminal aortic aneurysm repair. *J Vasc Surg* 2001;33:S33-8.
- Chong A, Soulen MC, Baum RA, Shlansky-Goldberg RD, Yee DC, Carpenter JP, et al. Balloon embolization of the internal iliac artery before aneurysm endograft deployment. *J Vasc Interv Radiol* 2001;12:637-9.
- Cynamon J, Lerer D, Veith FJ, Taragin BH, Wahl SI, Lautin JL, et al. Hypogastric artery coil embolization prior to endoluminal repair of aneurysms and fistulas: buttock claudication, a recognized but possibly preventable complication. *J Vasc Interv Radiol* 2000;11:573-7.
- Halloul Z, Burger T, Grote R, Fahlke J, Meyer F. Sequential coil embolization of bilateral internal iliac artery aneurysms prior to endovascular abdominal aortic aneurysm repair. *J Endovasc Ther* 2001;8:87-92.
- Karch LA, Hodgson KJ, Mattos MA, Bohannon WT, Ramsey DE, McLafferty RB. Adverse consequences of internal iliac artery occlusion during endovascular repair of abdominal aortic aneurysms. *J Vasc Surg* 2000;32:676-83.
- Lee CW, Kaufman JA, Fan CM, Geller SC, Brewster DC, Cambria RP, et al. Clinical outcome of internal iliac artery occlusions during endovascular treatment of aortoiliac aneurysmal diseases. *J Vasc Interv Radiol* 2000;11:567-71.
- Lee WA, O'Dorisio J, Wolf YG, Hill BB, Fogarty TJ, Zarins CK. Outcome after unilateral hypogastric artery occlusion during endovascular aneurysm repair. *J Vasc Surg* 2001;33:921-6.
- Mehta M, Veith FJ, Ohki T, Cynamon J, Goldstein K, Suggs WD, et al. Unilateral and bilateral hypogastric artery interruption during aortoiliac aneurysm repair in 154 patients: a relatively innocuous procedure. *J Vasc Surg* 2001;33:S27-32.
- Razavi MK, DeGroot M, Olcott C III, Sze D, Kee S, Semba CP, et al. Internal iliac artery embolization in the stent-graft treatment of aortoiliac aneurysms: analysis of outcomes and complications. *J Vasc Interv Radiol* 2000;11:561-6.
- Schoder M, Zaunbauer L, Holzenbein T, Fleischmann D, Cejna M, Kretschmer G, et al. Internal iliac artery embolization before endovascular repair of abdominal aortic aneurysms: frequency, efficacy, and clinical results. *AJR Am J Roentgenol* 2001;177:599-605.
- Wolpert LM, Dittrich KP, Hallisey MJ, Allmendinger PP, Gallagher JJ, Heydt K, et al. Hypogastric artery embolization in endovascular abdominal aortic aneurysm repair. *J Vasc Surg* 2001;33:1193-8.
- Yano OJ, Morrissey N, Eisen L, Faries PL, Soundararajan K, Wan S, et al. Intentional internal iliac artery occlusion to facilitate endovascular repair of aortoiliac aneurysms. *J Vasc Surg* 2001;34:204-11.
- Faries PL, Morrissey N, Burks JA, Gravereaux E, Kerstein MD, Teodorescu VJ, et al. Internal iliac artery revascularization as an adjunct to endovascular repair of aortoiliac aneurysms. *J Vasc Surg* 2001;34:892-9.
- Parodi JC, Ferreira M. Relocation of the iliac artery bifurcation to facilitate endoluminal treatment of abdominal aortic aneurysms. *J Endovasc Surg* 1999;6:342-7.
- Fillinger MF. New imaging techniques in endovascular surgery. *Surg Clin North Am* 1999;79:451-75.
- Fillinger MF. Postoperative imaging after endovascular AAA repair. *Semin Vasc Surg* 1999;12:327-38.
- Fillinger MF. Imaging of the thoracic and thoracoabdominal aorta. *Semin Vasc Surg* 2000;13:247-63.
- Fillinger MF, Weaver JB. Imaging equipment and techniques for optimal intraoperative imaging during endovascular interventions. *Semin Vasc Surg* 1999;12:315-26.
- Connolly JE, Ingegno M, Wilson SE. Preservation of the pelvic circulation during infrarenal aortic surgery. *Cardiovasc Surg* 1996;4:65-70.
- Hassen-Khodja R, Pittaluga P, Le Bas P, Declémy S, Batt M. Role of direct revascularization of the internal iliac artery during aortoiliac surgery. *Ann Vasc Surg* 1998;12:550-6.
- Paty PK, Shah DM, Chang BB, Darling RC III, Leather RP. Pelvic ischemia following aortoiliac reconstruction. *Ann Vasc Surg* 1994;8:204-6.
- Pittaluga P, Batt M, Hassen-Khodja R, Declémy S, Le Bas P. Revascularization of internal iliac arteries during aortoiliac surgery: a multicenter study. *Ann Vasc Surg* 1998;12:537-43.

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DISCUSSION

Dr Frank J. Veith (Bronx, NY). I often wonder why there is such intense interest in the hypogastric artery and its preservation, and I am glad to see that this interest continues. I suppose the reason that I was asked to discuss this paper is that we are considered among those who advocate the wanton sacrifice of this vessel during EVAR. Our reputation as hypogastric killers is based on a paper that Manny Mehta and we published describing the relative safety of hypogastric interruption during both EVAR and open repair, something that I have been doing, when absolutely necessary to treat aortoiliac aneurysms, for more than 20 years.

Over these 20 years, we have sacrificed one hypogastric artery in this setting more than 180 times and both hypogastrics 34 times. We have never had a serious problem, although about 15% of the patients have persistent buttock claudication. We know that others, among them the present authors, have had colon ischemia and

neurologic complications. But we have not yet. We believe, therefore, that embolization, hypotension, and other factors contribute to these serious complications of hypogastric interruption.

Having said that, we try to save the hypogastric if possible and we even reimplant it if we can. However, with fat patients, hypogastric aneurysms or heavily calcified vessels, it is often impossible or not worth the effort. Branched grafts may help, but I doubt it. Vessels in this setting are often too tortuous for these branched vessels.

Now to Dr Wyers' very fine paper. One of the authors' main conclusions is that hypogastric coil embolization may not be necessary in a substantial number of patients undergoing EVAR. I certainly agree with this conclusion. Indeed, I am sure everyone in the room does. The only problem discussing this paper from my perspective is that I generally agree with most of the points the Dartmouth group makes.

The points I agree with are: avoid sacrificing one hypogastric if you can; definitely avoid taking both if you can. The problem is that sometimes you cannot. And being saddled with a rather difficult group of patients at our institution, we have had to occlude one or both hypogastriacs more often than we would like.

Next, we agree with occluding the hypogastric with coverage rather than coils, if you can. It is certainly safer and avoids the risk of catheter wire-induced embolization, which we have now had in three cases. We have therefore covered rather than coiled whenever we could. However, if the distal common iliac is flared, as Dr Wyers pointed out, that is, there is no cylindric landing zone, coils are necessary. I guess we would like a 1-cm landing zone whereas the authors accept 0.5 cm. In addition, we have sometimes used a Palmaz stent to seal the landing zone. Dr Wyers, have you ever done that?

Finally, we avoid hypogastric branched coils, but sometimes with hypogastric aneurysms you cannot do that. It does not seem to matter because rich collaterals from the deep femoral arteries supply the pelvis. And in Dr Mehta's paper from our institution, we showed some of those collaterals. The authors agree about the importance of the deep femoral collaterals in supplying the pelvic circulation.

So, we seem to agree with the authors, and maybe that will help me get my reputation as a hypogastric saver back. However, it is the patient's anatomy that is the problem. One has to do whatever one has to do to exclude the aneurysm if it really needs fixing.

I enjoyed the paper. I enjoyed discussing it.

Dr Mark C. Wyers. Thank you, Dr Veith, for your kind comments and insightful discussion.

I think if you talked to us 4 years ago, we would have had a much more conservative approach to occlusion of the hypogastric. But partially due to some of the work you have published and that others have done, we now have a much more aggressive approach to occluding the hypogastric by both methods. And, as I mentioned, about half to two thirds of the time, based on this data, there is an adequate 5-mm seal in the distal common iliac to occlude the hypogastric without coiling.

With regards to stenting across the seal zone, we have done that. Most of the patients in our series involve supported stent grafts, which provide adequate support across the entire origin of the hypogastric. In grafts like the Ancure device that are not supported, we would advocate using a stent to help support the graft across the entire seal zone.

I think the incidence of deep pelvic collaterals is very important. Different people have tried to predict who is going to have buttock claudication problems and who will not. Unfortunately, it is virtually impossible to sort this out preoperatively. In addition to your work, Iliopoulos has published circulation studies regarding pelvic collaterals. The point he makes, and I would agree, is that the important collaterals are the deep ipsilateral collaterals—the ipsilateral circumflex femoral and iliolumbar collaterals—rather than cross pelvic collaterals. Because if you look at patients that have bilateral internal iliac occlusions (even simultaneous occlu-

sions), it is hard to sort out even among those patients who will have symptoms and who will not. So, I think the deep femoral collaterals are the important ones to think about.

Dr Bruce J. Brenner (Millburn, NJ). Two of the issues that you brought up I thought were pretty interesting. One was the importance of what I think in your institution is exquisite imaging, which allows you to make some of these decisions prior to angiography. The other issue concerned the technical aspects of coil placement: where do you place the coils, how late do you wait between the coiling and the aneurysm repair, do you avoid placing them in the collaterals?

Dr Wyers. Without a doubt we are lucky to have the imaging software that we do. We have helped develop the software through the past 5 years or so, and it is really at a point now where it provides outstanding detail, especially of the iliac anatomy, including evaluation of the tortuosity and other considerations. So certainly, it is necessary when you are scrutinizing this area for seal.

All of our coil embolizations are done by the surgeons in our group, in the operating room at the time of EVAR. Other groups make an effort to stage coiling and EVAR. That may be because they are used to getting a preoperative arteriogram and coiling the IIA in that setting. But we feel pretty confident that doing them at the time of endograft placement is safe to do and saves the patient a second procedure. And based on our results, at least with respect to unilateral coiling, there is really no difference between staging or not. I think in circumstances where bilateral coverage is planned we advocate and have staged the hypogastric occlusions. We do those at least 2 or 3 weeks apart, the second at the time of EVAR.

Dr Brenner. If you do your own diagnostic angiograms, do you place coils at that time?

Dr Wyers. I think a lot of people do that. We do not routinely do preoperative angiography. The only preoperative imaging we use is the CT angiography with 3D reconstruction software, so that is one of the reasons we do it in the operating room.

Dr Mark A. Adelman (New York, NY). I was interested in your graft limb occlusions. I think you indicated that you had two limb occlusions on the side of the hypogastric coverage. One might envision that if there is a back pressure coming from the hypogastric orifice, pushing against an unsupported graft, that it could cause a kink or an indentation in an unsupported graft. Do you know whether those two occlusions were in supported or unsupported grafts, and do you think that makes a difference?

Dr Wyers. They were both in supported grafts. The late occlusion we had was at about 28 months postprocedure and in that patient was clearly related to shrinkage of the aneurysm and deformation of the entire aneurysm sac. So the actual kink that led to the occlusion occurred very high up in the graft limb.

The second, more acute occlusion happened 2 weeks post EVAR, also in a supported graft. In that patient, it was hard to sort out the exact cause. Unfortunately, this occlusion was treated at an outside hospital with a fem-fem bypass only. In reviewing his preoperative studies, however, there was nothing about the external iliac artery diameter that would have made you think he would have been at higher risk for limb thrombosis.